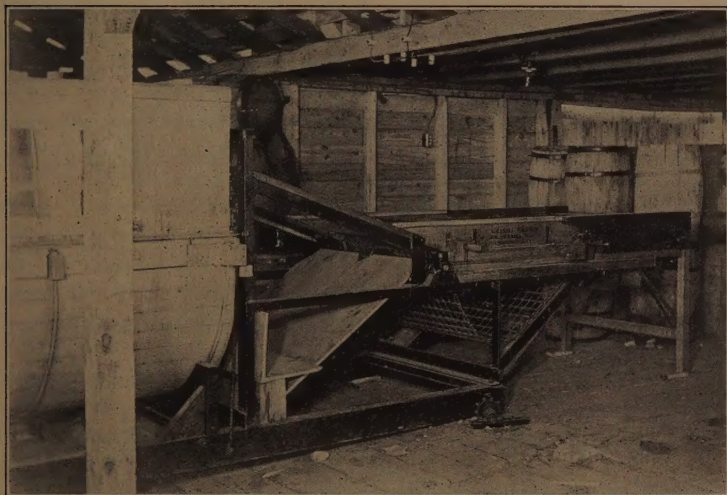
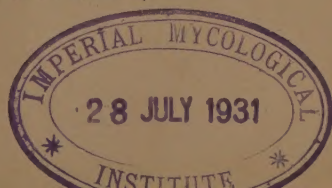

VIRGINIA POLYTECHNIC INSTITUTE
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Eliminator installed ahead of the washing machine. It is advisable to eliminate culls as well as undersized fruit before the washing treatment

Removal of Spray Residue from Apples

By W. S. HOUGH, R. H. HURT, W. B. ELLETT, J. F. EHEART,
and A. B. GROVES



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By W. S. HOUGH, R. H. HURT, W. B. ELLETT, J. F. EHART,
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INTRODUCTION

This publication is intended to make available information relative to the problem of removing spray residue from Virginia apples. Nearly all Virginia apples are packed in barrels or baskets and consequently the methods used in handling the crop during the packing season differ from the methods used in the "box-apple" sections of the West where fruit washing has been practiced since 1926. Furthermore, the use of fungicides is general in Virginia and residues from these materials as well as occasional insect residues such as leafhopper specking or honey dew from aphids make our problems of cleaning the fruit somewhat different.

The 1926 spray program for Virginia orchards was limited to three arsenical applications in May and June. On July 28, 1926, an experimental block of York Imperial trees in a large orchard near Winchester was given a fourth arsenical spray, which was timed for control of second brood codling moth larvae. The fruit picked from the experimental trees from late September to late October carried an excessive amount of residue (average 0.016 gr. to 0.026 gr. As_2O_3 per pound), although the total rainfall exceeded ten inches from August 1 to September 24 when the first picking was made.

In 1927 and 1928 the fourth arsenical application on apples was completed during the first two weeks of July and the fruit did not carry excessive amounts of spray residue at picking time.

In 1929 four arsenical sprays and in 1930 three arsenical sprays were applied in May and June without requiring removal of arsenical residues at picking time. But in many orchards where an arsenical spray was applied between July 1 and 19, 1930, there remained an excessive amount of residue on the fruit at picking time, regardless of whether the July spray was the third or fourth application containing lead arsenate.

Fruit sprayed during the first half of July in 1930 carried an excessive amount of residue for the remainder of the season, because normal growth of the fruit from July to the end of the season was prevented by the drouth. It has been shown in New Jersey¹ that apples normally develop only one-half of

¹ C. C. Hamilton: Growth and spray coating. Jour. Econ. Entomology, Vol. 22, No. 2, pp. 387-396, April, 1929.

Note: This bulletin was prepared by Dr. Hough, who also obtained the data given in Tables 1, 2, 3, and 4. The data given in Tables 5 and 6 were obtained by Mr. Hurt, who cooperated with the Department of Agricultural Chemistry in the analyses reported. Mr. Groves contributed to the paragraphs on washing storage fruit.—W. J. Schoene.

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their final diameter, one-fourth of their final surface area, and one-seventh to one-ninth of their final volume by the end of June. When normal development is checked near the time the last spray is applied, it appears that the chief factor in reducing spray residue per unit volume or weight is eliminated.

DISTRIBUTION OF ARSENICAL RESIDUE ON THE FRUIT

It was thought that efficiency of cleaning the fruit might depend in part on the distribution of the arsenical residue on the apples. Consequently, in the fall of 1926 apples were picked from various parts of several trees of the York Imperial variety, which had received the petal-fall and three cover sprays containing arsenate of lead. The arsenical analyses were kindly made by the Bureau of Chemistry of the U. S. Department of Agriculture and are given in Table 1. Determinations made in other parts of the country² show somewhat similar distribution of the arsenical residue on other varieties.

Table 1.—Distribution of arsenical residue on York Imperial apples,
Winchester, Va., 1926

Sample number	AMOUNT OF As_2O_3 PER APPLE							Grain of As_2O_3 per pound of fruit
	On skin		In stem end		In calyx end		Total	
	Grain	Per cent	Grain	Per cent	Grain	Per cent	Grain	
1.-----	0.0011	58.0	0.0003	15.7	0.0005	26.3	0.0019	0.0066
2.-----	0.0013	50.0	0.0008	30.7	0.0005	19.3	0.0026	0.0102
3.-----	0.0023	59.0	0.0008	20.5	0.0008	20.5	0.0039	0.0133
4.-----	0.0022	56.5	0.0008	20.5	0.0009	23.0	0.0039	0.0156
Average-----		55.87		21.85		22.28		

WIPING²

"Under Virginia conditions, will the polishing machines remove sufficient quantities of spray residue to meet requirements for marketing?" This question has been raised by many fruit growers who regularly use brushing or wiping machines for the purpose of polishing the fruit as it is packed. Effectiveness of the wiping treatment is best summarized in Table 2 for fruit testing above the world tolerance of 0.01 grain of arsenic trioxide per pound and Table 3 for fruit testing within this tolerance.

Fruit was run through machines which had been used for some time as well as new machines which had not yet been used. The latter were, therefore, uncontaminated by spray residue from the fruit. In some instances the fruit was run through two machines or through the same machine two times. Most of the fruit ranged from $2\frac{1}{4}$ to $2\frac{1}{2}$ inches in diameter, except the North-

² Washington Agri. Exp. Sta. Bulletin 213, p. 28, Mar., 1927. Jour. Econ. Ent., Vol. 21, No. 6, p. 325, Dec., 1928.

³ Thanks are due W. Catesby Jones and H. H. Shockey, Division of Chemistry, Virginia State Department of Agriculture, for making many of the arsenical analyses given in Table 2.

western Greenings which were about $2\frac{3}{4}$ to 3 inches in diameter. It will be observed from Table 2 that wiping was more consistently effective on the larger apples.

Table 2.—Results of wiping fruit which carried spray residue in excess of world tolerance of 0.01 gr. As_2O_3 per pound of fruit, Winchester, Va., 1930

Variety and date	Grain of As_2O_3 per pound		Residue removed	Method of wiping
	Unwiped	Wiped		
	Grain	Grain	Per cent	
YORK IMPERIAL ($2\frac{1}{4}$ — $2\frac{1}{2}$ in.)				
August 14, 1930	0.045	0.006	86	Bean-Moe, new
August 15, 1930	0.022	0.017	23	Bean-Moe, new
		0.013	40	Trescott, new
		0.017	23	Skinner, new
August 15, 1930	0.018	0.014	22	Skinner, new
September 5, 1930	0.035	0.033	6	Bean-Moe, new
		0.028	20	Bean-Moe, new (two times)
September 5, 1930	0.021	0.012	43	Bean-Moe, used
September 24, 1930	0.036	0.027	25	Bean-Moe, used
November 22, 1930	0.032	0.015	53	Bean-Moe, used
		0.016	50	Trescott, used
October 16, 1926	0.020	0.012	40	Hand cloths
November 1, 1926	0.011	0.006	45	Canvas gloves
Average removal from 13 samples			36	
JONATHAN ($2\frac{1}{4}$ — $2\frac{1}{2}$ in.)				
August 25, 1930	0.016	0.011	31	Bean-Moe, used
August 29, 1930	0.014	0.008	43	Bean-Moe, used
		0.012	14	Bean-Moe, used
		0.011	21	Bean-Moe, used (two times)
September 5, 1930	0.023	0.013	43	Bean-Moe, used
September 5, 1930	0.030	0.010	56	Bean-Moe, used (two times)
		0.016	45	Bean-Moe, used
Average removal from 7 samples			36	
GRIMES GOLDEN (mostly $2\frac{1}{4}$ in.)				
August 15, 1930	0.044	0.013	71	Bean-Moe, new
August 26, 1930	0.022	0.020	10	Bean-Moe, used
September 5, 1930	0.038	0.030	21	Bean-Moe, new
		0.020	48	Bean-Moe, new (two times)
September 5, 1930	0.023	0.015	35	Bean-Moe, new
		0.011	52	Bean-Moe, new (two times)
Average removal from 6 samples			39	
NORTHWESTERN GREENING ($2\frac{3}{4}$ —3 in.)				
August 25, 1930	0.025	0.008	68	Bean-Moe, new
August 30, 1930	0.020	0.003	85	Bean-Moe, used
		0.005	75	Bean-Moe, used (two times)
Average removal from 3 samples			76	
KING DAVID ($2\frac{1}{4}$ in.)				
September 5, 1930	0.016	0.014	12	Bean-Moe, new
STAYMAN-WINESAP ($2\frac{1}{2}$ in.)				
September 5, 1930	0.020	0.010	50	Hand cloths

From the results on spray residue removal by wiping, certain points are apparent. (1) There was little difference in efficiency of the types of commercial wiping machines used, that is, between the cloth polisher and the brushing machines. (2) There was remarkable variation in the amount of arsenical residue removed, the highest being 86 per cent and the lowest 6 per cent for fruit testing above the world tolerance. (3) Size of fruit appears

Table 3.—Results of wiping fruit which did not exceed world tolerance of 0.01 gr. As_2O_3 per pound of fruit, Winchester, Va., 1930

Variety and date	Grain of As_2O_3 per pound		Residue	Method of wiping
	Unwiped	Wiped		
YORK IMPERIAL: (2¼—2½ in.)				
September 5, 1930.....	0.010	0.006	Decreased 40%	Bean-Moe, new
September 5, 1930.....	0.009	0.012	Increased 33%	Bean-Moe, used
September 24, 1926.....	0.002	0.003	Increased 50%	Hand cloths
STAYMAN-WINESAP: (2½ in.)				
November 22, 1930.....	0.007	0.007	No change	Bean-Moe and Trescott, both used
		0.006	Decreased 14%	Trescott, used

to be one of the factors influencing residue removal. The average removal from fruit sizing 2½ inches and less was only slightly greater than one-third of the total residue on the fruit. Furthermore, when apples of different sizes were run at the same time, there was a tendency for the larger fruits to protect the smaller apples from the wiping action of the brushes or cloths. (4) Wiping fruit which tested within the world tolerance (Table 3) yielded very erratic results, in that only two of the five wiped samples showed a decrease in the amount of residue remaining on the fruit while two samples showed an increase and one no change at all. It appears probable that contaminated brushes or cloths may sometimes add residue to fruit, which previously carried only a small amount of spray material. (5) Double wiping, that is, passing the fruit through the same machine two times or through two machines was only very slightly more effective than single wiping and would probably not justify the extra expense involved.

The experience of wiping large quantities of the 1930 crop in Virginia indicated that (1) wiping was not sufficient to bring all of the fruit within the world tolerance, and (2) if removal of more than one-fourth to one-third of the residue is required to meet a desired tolerance, the wiping method of cleaning is not dependable to meet the needs. This is true especially for fruit which sizes not over 2½ inches in diameter.

WASHING

During the season of 1930 various types of acid washing equipment were used in removing spray residue from Virginia apples. This equipment included dipping vats, flotation washers equipped with paddles or conveyors, and three types of commercial washers made in the West. A brief summary of the operation of the various equipment studied by the authors is given here.

Dipping

Three men dipped (Figure 1) and rinsed an average of 500 crates of fruit per day. The acid vat was large enough (inside measurements 18 x 37 x 64 in.) to accommodate four crates at one time. Each crate remained in the acid solution approximately one minute, after which it was transferred to a water vat. The water in this vat was kept alkaline by the addition of a handful of hydrated lime at intervals of about 30 minutes. After removing from the vat, one gallon or more of fresh water was sprayed into each crate. When the fruit was allowed to dry in the crates, reddish deposits of sediment adhered to the apples in the lower part of each box. In order to avoid this objectionable feature the fruit was run over the grader soon after being rinsed. No injury to the fruit has been observed or reported from dipping operations. Growers, however, will do well to use this method with caution and only in emergencies. Arsenical injury and core rot have been more or less common following dipping operations in the Pacific Northwest.

Flotation Washers

These machines were of two kinds, the paddle washer (Figure 2) and washer with immersed conveyor. Paddle washers made according to specifications of the U. S. Department of Agriculture, but equipped with sprocket wheels to increase speed, washed from 160 to 300 barrels of graded fruit per



Fig. 1.—An emergency method of removing spray residue. Three men dipped and rinsed 500 crates per day

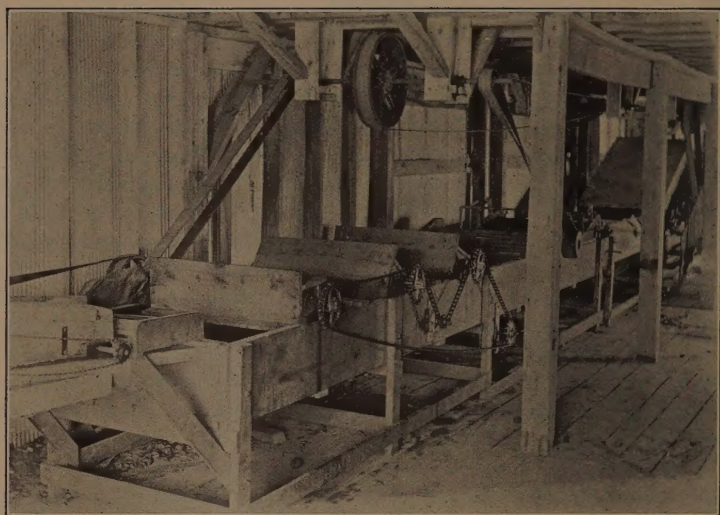


Fig. 2.—The paddle washer successfully removed spray residue but did not dry the fruit. Note cloth wiping machine into which the wet fruit was passed. The wiper removed all smears and much moisture but bruised some of the apples

day throughout the picking season. Slightly larger machines of the same design washed regularly from 200 to 375 barrels of graded fruit per day.

The average amount of fresh water rinse was one gallon for each crate of fruit washed. This amount was sufficient when delivered on the fruit through spray nozzles in place of perforated pipes.

Paddle washers were satisfactory for removing arsenical residue. Many of the home-made machines, however, gave more or less trouble mechanically. Conveyors stalled, fruit was crushed, sprocket wheels failed to hold and chains broke. Aside from mechanical difficulties the chief disadvantage in using the paddle washers was the absence of any drying unit. Efforts to dry the fruit by currents of air from elaborately constructed fans, and passing the fruit over hair brush machines or under blankets, were without value and were usually abandoned after a fair trial.

Commercial Washing Machines

Both the diffused spray and flood type of Western machines were used. In every instance efforts were made to increase the capacity by speeding up the conveyor. Machines of largest capacity obtainable were too small for the capacity desired in a number of cases. Some of the machines with steel rod conveyors were speeded up until they washed two times their rated capacity.

Machines with shuffleboard conveyors did not exceed their rated capacity at any time. Removal of arsenical residues was satisfactory wherever these machines were used.

Acid Solution ⁴

One gallon of commercial hydrochloric acid (20° Baumé and about 32.1 per cent acid) was usually used in 100 gallons of wash solution. When the day temperature dropped below 60 degrees in October and where the residue was considerably above the average, the strength of the solution was often increased to two gallons of acid in 100 gallons of wash solution.

The amount of acid used in a day's run when 1,800 to 2,200 bushels of fruit were washed is shown in Table 4. The data given in this Table are representative of the daily records kept through the packing season on the operation of the two commercial washing machines in the Valley Fruit

⁴ Strength of the acid solution is nearly always given in per cent of actual acid present. It should be remembered that commercial hydrochloric acid contains approximately one part of acid and two parts of water by volume. The following amount of commercial hydrochloric acid in 100 gallons of wash solution gives the per cent acid strength as indicated:

- 1 gallon = $\frac{1}{4}$ % acid solution (about 3.2 on scale of 10 cc. pipette)
- 2 gallons = $\frac{1}{2}$ % acid solution (about 6.4 on scale of 10 cc. pipette)
- 3 gallons = 1% acid solution (about 9.7 on scale of 10 cc. pipette)

Table 4.—Showing per cent strength of acid solution and the addition of hydrochloric acid during typical daily runs of two commercial washing machines of the diffused spray type, each of which washed a minimum of 1,800 bushels of fruit in 10 hours. Winchester, Va., 1930

(Capacity of acid tank, 200 gallons. Acid solution completely renewed each morning.)

Date	WASHER NO. 1				WASHER NO. 2			
	Time of observation	STRENGTH OF ACID WASH			Time of observation	STRENGTH OF ACID WASH		
		Before adding acid	After adding acid	Amount of acid added		Before adding acid	After adding acid	Amount of acid added
		Per cent	Per cent	Gallons		Per cent	Per cent	Gallons
October 4-----	7:15 a. m.		0.40	2.0	7:15 a. m.		0.38	2.0
	10:30 a. m.	0.32	0.41	1.0	11:00 a. m.	0.30	0.38	1.7
	1:30 p. m.	0.35	0.40	0.5	1:15 p. m.	0.37		0.0
	3:15 p. m.	0.32	0.40	0.5	3:00 p. m.	0.35	0.39	0.5
				4.0				4.2
October 11-----	7:15 a. m.		0.36	2.0	7:15 a. m.		0.49	2.0
	10:15 a. m.	0.36	0.37	1.0	10:20 a. m.	0.44	0.42	1.5
	1:00 p. m.	0.33	0.46	1.0	1:15 p. m.	0.42	0.42	0.5
	3:30 p. m.	0.46	0.50	0.5	3:30 p. m.	0.42	0.36	0.5
				4.5				4.5
October 25-----	7:00 a. m.		0.70	4.0	7:00 a. m.		0.70	4.0
	10:00 a. m.	0.65	0.69	1.0	10:00 a. m.	0.70	0.69	1.5
	1:00 p. m.	0.67	0.72	1.5	1:00 p. m.	0.69	0.67	1.5
	3:00 p. m.	0.66	0.72	1.5	3:00 p. m.	0.64	0.80	2.0
				8.0				9.0
October 27-----	7:00 a. m.		0.75	4.0	7:00 a. m.		0.74	4.0
	10:00 a. m.	0.75	0.72	1.5	10:00 a. m.	0.73	0.76	2.5
	1:00 p. m.	0.70	0.74	1.5	1:00 p. m.	0.76	0.72	1.0
	4:15 p. m.	0.73	0.78	1.5	4:20 p. m.	0.68	0.79	2.0
				8.5				9.5

Exchange at Winchester. Before starting the day's run the acid tanks were drained, cleaned, and filled with fresh acid solution. The strength of the solution was tested at the beginning of the run, about the middle of the morning, during the noon hour, and about the middle of the afternoon, at which times water and acid were added according to requirements. When the strength of the acid bath was maintained near the dilution of one gallon of commercial hydrochloric acid in 100 gallons of wash solution, a total of 4 to 4.5 gallons of hydrochloric acid was required for the day's run. From 8 to 9.5 gallons of acid were required when the strength of the acid solution was kept near the dilution of 2 gallons of commercial acid in 100 gallons of wash solution.

It will be observed (Tables 4 and 5) that the acid solution did not lose strength rapidly and that it was only necessary to add more acid when water was added to make up the loss in volume from the washing operations. The continuous use of the same acid solution for a period of 5 hours without the addition of either acid or water (Table 5) did not as a rule greatly change the efficiency of the bath. In some instances the efficiency of the bath tended to increase after it had been used a short time. This was probably due to the presence of particles of dirt washed from the fruit and suspended in the solution, which when sprayed on the fruit, had more abrasive action than a fresh, clear solution.

It was considered advisable to renew the acid solution completely in the home-made washers after washing from 600 to 1,000 barrels of graded fruit.

Fresh Water Rinse

The fresh water rinse is intended to remove the acid solution and dissolved spray residue from the fruit. For this reason it is the most important operation in connection with washing fruit. During the season of 1930 growers were usually able to keep the acid solution near a given strength, but it was necessary to stress the importance of more rinse water in a majority of instances. Rinsing was greatly improved on the home-made type of washers by using six or eight spray nozzles (Figure 3) to deliver the fresh water on the fruit as it was conveyed out of the water bath. Less water was required to rinse the fruit satisfactorily than when perforated pipes were used. For each bushel of washed fruit one gallon of fresh water sprayed on the apples by means of the nozzle system was sufficient to remove traces of acid taste and in all cases gave satisfactory results. In other words, from 3 to 3½ gallons per minute for the home-made washers and 3 to 5 gallons per minute for the commercial washers was the usual amount of water required for satisfactory rinsing.

In one orchard where no running water was available the water bath (100-gallon capacity) was renewed four times daily, at 7 and 9:30 a. m., at



Fig. 3.—Fresh rinse water delivered through spray nozzle at the rate of one gallon for each bushel of fruit washed removed all traces of acid from the apples

noon, and at 3:30 p. m. From two to three pounds of hydrated lime was placed in the water bath soon after each renewal in order to neutralize the acid. By simply tasting the rinse water on the fruit one can easily detect slight traces of acid, for the sharp biting or “salty” taste of acid is an accurate test for its presence in the water. If the “salty” taste was detected in the water bath, more lime was added or the bath was renewed. An average of 200 to 250 barrels of graded fruit was washed daily in the paddle washer and rinsed by this method.

Drying

The efficiency of the air drying system on commercial washers depended on the rate at which fruit was washed. As the speed of the machine was increased beyond the rated capacity, air drying became less efficient. Fruit carrying deposits of sulphur fungicides, dust or heavy deposits of Bordeaux mixture sometimes presented a smeared appearance after being washed and either passed through an air drying unit or allowed to dry by evaporation. From the standpoint of drying and cleaning fruit of leafhopper specking, dirt and smears of various residues, including fungicides, the towel drying units (Figure 4) were the most satisfactory systems observed. In addition, the process of wiping tended to polish the fruit so that it had a brighter and

Table 5.—Residue removed by commercial washers (diffused spray type of 500 bushels capacity) operated at a speed which carried the fruit through the acid bath in about 20 seconds, Greenwood and Charlottesville, Va., 1930

Variety and date	THE ACID BATH		Analysis, Grain As ₂ O ₃ per pound	Residue removed
	Strength of solution	Hours in use without renewing		
	<i>Per cent</i>			<i>Per cent</i>
ALBEMARLE PIPPIN:				
September 9.....	0.38	0.5	0.008	79
	0.37	2.0	0.011	71
	0.36	3.5	0.003	92
	0.34	5.0	0.005	87
Check, not washed.....			0.039	
ALBEMARLE PIPPIN:				
September 10.....	0.39	1.0	0.004	71
	0.38	2.0	0.004	71
Check, not washed.....			0.012	
	0.37	3.0	0.007	50
	0.35	5.0	0.012	14
Check, not washed.....			0.014	
ALBEMARLE PIPPIN:				
September 13.....	0.42	0.0	0.002	81
		1.0	0.003	72
	0.40	2.0	0.001	91
	0.39	3.0	0.004	63
	0.38	4.0	0.004	63
Check, not washed.....			0.011	
WINESAP:				
October 16.....	0.33	0.0	0.004	60
	0.32	1.0	0.003	70
	0.32	2.0	0.002	80
	0.31	3.0	0.003	70
	0.30	4.0	0.003	70
	0.29	5.0	0.003	70
Check, not washed.....			0.010*	

*Average of two samples.

cleaner appearance. The only practical method of removing the leafhopper specking (Figure 5) proved to be washing the fruit in a commercial washer equipped with a towel drying unit. The action of the acid solution and the water rinse soaked the specks sufficiently for the towels to remove all of the specking and sooty smears, except for an occasional spot deep in the stem end of the fruit.

Home-made air drying systems, including the use of large fans of all kinds, proved to be worthless. Passing the wet fruit over hair brush machines also failed to give any degree of dryness to the fruit.

The importance of drying the fruit may be considered from more than one point of view. Packing wet fruit in barrels and baskets as well as boxes does not seem to affect its keeping quality. Nevertheless, there exists the desire to avoid placing wet fruit in barrels or baskets. When wet fruit is run over a dusty grading machine there is always an unsightly smear on the apples. Furthermore, on certain types of graders wet fruit will pile up on the canvas belts so that the sizing machinery will not function. Lastly, results from packing wet fruit which has been exposed to late scab infection are unknown at the present time.

Washing Storage Fruit

It is more difficult to remove spray residue from storage fruit because of the low temperature that prevails in storage and also because of the increased amount of wax on the fruit. The temperature of the acid solution in the

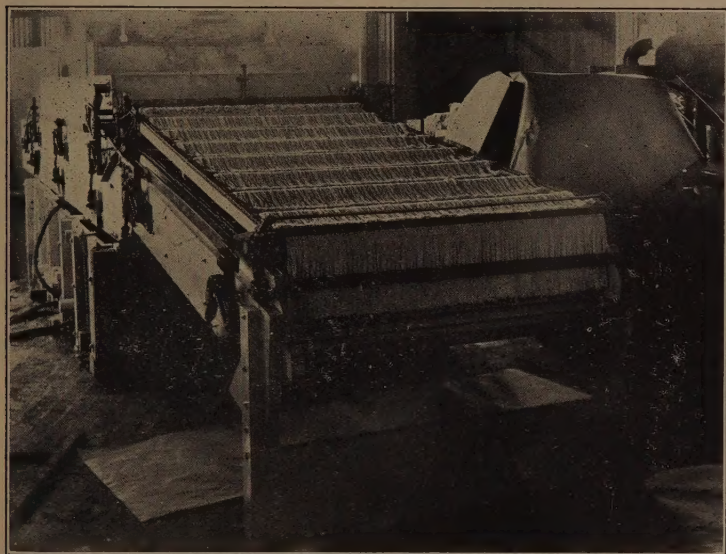


Fig. 4.—The towel drying unit removed moisture as well as smears from fungicides, dirt, and insect residue

commercial washer used in the Winchester Cold Storage was less than 48°, the usual range being 40° to 45° F. Preliminary experiments showed that increasing the strength of the acid bath to 3 gallons of commercial acid in 100 gallons of wash solution did not remove sufficient residue from fruit testing above 0.016 gr. As_2O_3 per pound. The addition of 8 pounds of salt per 100 gallons aided slightly in residue removal, but it was not until the solution was heated (100° to 110° F.) that removal of residue was sufficient to bring all fruit within the world tolerance. The 200 gallons of wash solution (3 gallons acid per 100 gallons) was maintained at a temperature near 110° F. by injecting steam piped from a 16 h. p. traction engine, which was stationed outside of the storage building. Because of the dilution of the solution by condensed steam it was necessary to add acid (1 to 2 quarts per 100 gallons) each hour during the day's run.

Salt (8 pounds per 100 gallons) was usually added to the heated acid solution to increase efficiency in residue removal. When this was done it was necessary to add 2 or more pounds of salt per 100 gallons at intervals of 4 or 5



Fig. 5.—Leafhopper specking on the fruit (right) was removed only by washing machines equipped with a towel drying unit. Normal apple on left

hours in order to keep the solution up to strength. In this connection it should be stated that although salt increases the efficiency of the wash solution, it also increases corrosion and rate of depreciation of the washer.

Storage Condition of Washed Fruit

The data given in Table 6 show that fruit washed and properly packed in barrels compared favorably in storage with unwashed fruit. Large quantities of York Imperial, Ben Davis, and Stayman apples washed and stored at Winchester were observed at the time the fruit was moving out of storage during the winter months. No difference was noted in the keeping quality of washed and unwashed fruit.

Table 6.—Summary of observations on the storage condition of fruit washed in a commercial washer and packed in barrels. Albemarle Pippins washed September 10, 1930, and Winesaps on October 16, 1930, at Greenwood, Va.

Sample number	Variety	Treatment	Amount of acid in 100 Gal. of wash solution	How packed	Condition of fruit, March 17, 1931	
					Decay	Scald
					Per cent	Per cent
1.....	Albemarle Pippin	Washed	1 gal.	Without oil paper	2.0	10.6
2.....	Albemarle Pippin	Washed	1 gal.	Without oil paper	0.0	0.0
3.....	Albemarle Pippin	Washed	1 gal.	With oil paper	0.0	4.0
4.....	Albemarle Pippin	Washed	2 gal.	With oil paper	0.0	7.0
5.....	Albemarle Pippin	Washed	3 gal.	With oil paper	0.0	6.3
6.....	Albemarle Pippin	Wiped *		With oil paper	1.0	4.0
7.....	Winesap	Washed	1 gal.	Without oil paper	0.0	33.6
8.....	Winesap	Washed	1 gal.	With oil paper	0.0	0.0
9.....	Winesap	Check	Untreated	With oil paper	0.0	0.0

NOTE: No evidence of acid injury observed.

*Used Wayland brush machine.

Nearly all of the fruit washed in home-made paddle washers was wet or very damp when packed in barrels.

Cost

The cost of washing fruit in 1930 varied considerably because of methods used, arrangement of equipment in packing sheds, and extra labor required. Information available indicated that the washing treatment cost $2\frac{1}{2}$ cents to 6 cents per barrel of graded fruit. These figures did not include cost of washer or depreciation of equipment but merely operating expenses such as labor, power, and chemicals used. Washing storage fruit cost 12 cents to 15 cents per barrel.

The cost of washing apples in New Jersey varied according to the number of bushels washed annually by one machine. "Where a grower has only 5,000 bushels of fruit to wash per year, it will cost him 5 cents per bushel with the Bean washer, while if the number of bushels is 50,000, the cost will be only 1.5 cents.⁵" Five thousand bushels washed in a home-made paddle washer cost 1.75 cents per bushel, and dipped by hand 2.75 cents per bushel. The costs in New Jersey include depreciation, interest on investment, maintenance, and operating expenses.

CONCLUSIONS

1. Three sprays of 3 pounds of lead arsenate in 100 gallons of water applied in May and June has not required removal of spray residue from the fruit at picking time in September.

2. An arsenical spray applied during the first half of July may leave an excessive amount of residue on the fruit, if followed by dry weather for the remainder of the season.

3. An arsenical spray applied late in July left an excessive amount of residue on the fruit for the remainder of the season, although rainfall greatly exceeded the normal precipitation for August and September.

4. Approximately half of the arsenical residue is distributed on the side of the apple, the remainder being in the calyx and stem ends.

5. Average removal by wiping or brushing approximated one-third of the total arsenical residue on the fruit.

6. Washing fruit in a dilute hydrochloric acid solution consistently removed excessive arsenical residues.

⁵ H. C. McLean: The present cost of washing apples. N. J. State Hort. Soc. News, Vol. 2, No. 3, pp. 335-336, May, 1930.

7. For each bushel of washed fruit, one gallon of fresh rinse water, delivered through spray nozzles, removed traces of acid from the fruit. In practice this required 3 to 5 gallons of fresh water per minute.

8. The towel method of wiping and drying washed fruit was more satisfactory than air drying, because the former removed leafhopper specking and smears from fungicides or dust.

9. Washed fruit kept as well as unwashed fruit when packed and stored in barrels or baskets.